DESIGN OF A SYNCHRONOUS COLLABORATIVE LEARNING ENVIRONMENT

Simon Schwantzer, Dirk Henrici
Integrated Communication Systems, University of Kaiserslautern, Paul-Ehrlich-Strasse, Kaiserslautern, Germany
schwantzer@informatik.uni-kl.de, henrici@informatik.uni-kl.de

Paul Mueller
Integrated Communication Systems, University of Kaiserslautern, Germany
pmueller@informatik.uni-kl.de

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Abstract: In complex fields of knowledge, working in unmoderated small groups is a common approach for creating knowledge out of given information. Taking a look at the portfolio of learning environments, only a few systems provide the necessary functionality for synchronous collaboration. In most of them, synchronicity is reduced to communication. The aim of this work is the design of a synchronous collaboration environment which fulfills the requirements to enable members of a small group working together efficiently via computer networks. Based on the three elements communication, cooperation and coordination, a concept for an appropriate groupware is created and a flexible model defined. A sample environment called "SLE" is developed to demonstrate the applicability.

1 INTRODUCTION

Learning in complex scenarios is difficult to be done by an individual alone. A common approach to handle even sophisticated learning scenarios is collaborative work in small groups. In these scenarios, learning is based on different persons having a comparable level of knowledge but different views on the subject. The required information is available and provided in different forms such as books, scripts, and exercises. The information is transformed into knowledge through close collaboration of the group.

Common environments for distributed learning - like Learning Management Systems - focus on loose, asynchronous collaboration. Close and therefore synchronous collaboration is often only supported by small communication tools like text, audio, or video chats and whiteboard functionality. Aim of this work is to build a virtual environment designed to fulfill the requirements for a close, synchronous collaboration amongst a small group of learners.

To identify the requirements for such an environment, elementary works about close collaboration and learning have to be considered as well as existing solutions with a comparable functionality. Therefore, two areas of research, computer supported collaborative learning (CSCL) and computer supported cooperative work (CSCW), are relevant for the given scenario. Based on results of theoretical works and functionality of existing solutions, a basic model which fulfills the identified requirements is designed, which considers aspects of navigation, interaction, and cooperation.

A sample environment, so-called 'Synchronous Learning Environment', is introduced to demonstrate the applicability of the concept. Based on this implementation, first results of an evaluation are presented.

2 RELATED WORK AND REQUIREMENT ANALYSIS

The analyzed tools for distributed and synchronous cooperative work mainly divide into two classes: shared text editors and shared whiteboards. Shared text editors came up at the beginning of the 1990s. One of the first was *GROVE*. The underlying work (Ellis et al., 1991) introduced several important basics of groupware like concurrency issues and views. In (Dourish and Bellotti, 1992) the term 'awareness' was coined and extended with a new type, the so-called 'passive awareness mechanisms'. Part of this work is the implementation of an editor called *ShrEdit*. Beside this basic developments, newer representatives of shared text editors like *NetEdit* (Zafer et al., 2001) emerged, which implemented more recently developed improvements concerning awareness mechanisms and application design. Parallel to this, 'shared whiteboards' where examined, which were not restricted to simple text manipulation. An early representative of these is *wb*, part of the MBone groupware architecture (Eriksson, 1994). Aiming to share and annotate presentations, it offers simple drawing routines for all users. This concept was extended by *MediaBoard* (Tung, 1998). Based on the possibilities for interactive presentations, shared whiteboards where developed towards interactive conferencing systems like Adobe Connect Pro[1].

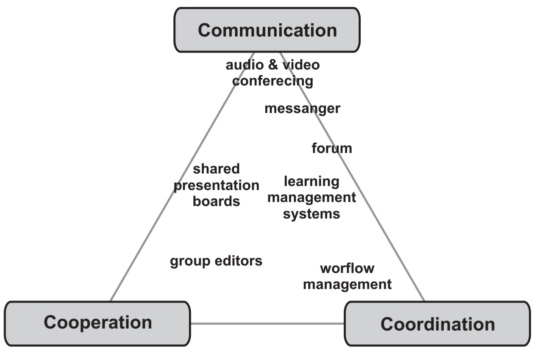

Figure 1: Different groupware in the 3C Model

Each collaborative technology can be divided into three parts: communication, cooperation, and coordination, see Figure 1. We can thus look at the parts separately and classify the requirements accordingly.

Basics of distributed **communication** were extracted from (Fuks et al., 2006). The optimal form of communication between human beings is a face-to-face conversation because there are no limitations to the communication channels. The available channels are voice, mimics, and gestures. In (Olson et al., 1995) text, voice and video chats were exermined for their value in small group collaboration. According to this study, high quality voice communication enables a distributed group to achieve the same results in collaboration as a local group. While a video communication is only of little additional value for the result, it is beneficial to the acceptance of a collaboration environment.

Elements of **coordination** are based on the above-named groupware solutions and their workspace awareness mechanisms. Main issue of coordination is the concurrency handling. The advantage of a more restrictive system is providing clearer role definitions and requiring less organization between the users. In the given scenario, roles are surely existent, but the role allocation is very dynamic. The role definition should be as dynamic as possible and the concurrency handling therefore less restrictive. With a less restrictive concurrency handling, the cost for organization between the users increases. Aiming to reduce this operative overhead, passive awareness mechanisms collect awareness information in the background and present them directly on the workspace.

In (Dwyer and Suthers, 2006) collaboration with artifact-mediated **cooperation** was analyzed. Cooperation is defined by the interaction of multiple users with a 'shared material'. The goal is to reclaim knowledge by structuring information, so this is the starting point to find an appropriate material for the environment. A common definition of 'knowledge' is 'networked information'. 'Information' is interpretable data. In the given scenario, we can work directly with information because it is already available.[2] According to this definition, the shared material is a workspace which allows to place and link information. The combination of a workspace, information objects, and links is named 'information space' below.

3 INFORMATION SPACE MODEL

The information space should provide a wide variety of information object types and good possibilities to structure information objects. On the other hand, the information space structure should be as simple as possible to avoid distracting the users from the content. A concept for an information space has to consider both requirements and therefore needs to find an adequate balance between them.

The simplest structure for an information space is a linear array of information objects. An example for a linear information space is pure text: the information objects are words, sentences or sections. The linkage is provided by their order. Linear information spaces are easy to access, but aside from the order of objects, there is no possibility of structuring information. The dimension has to be increased to enable those structuring mechanisms. This leads to a class of two-dimensional information spaces. A member of this class is the classic whiteboard. Following the common nomenclature for two-dimensional spaces,

[1] Adobe Connect Pro, Adobe Systems, http://www.adobe.com/de/products/acrobatconnectpro/

[2] In scenarios of moderated learning, the interpretation of data would be an additional step.

an information space with this structure is called 'information graph' in the following.

Many restrictions of classic whiteboards are ommited with the generalization to an information graph structure:

- **Workspace:** A virtual workspace needs not to be bounded. There are no restrictions to the level of detail a workspace can have.
- **Objects:** Information objects can be of any digitally representable form and are not restricted to text and graphic types. Objects can easily be manipulated, moved and removed.
- **Links:** Links are not restricted to symbols. They can be moved easily with the linked objects.

Beside text and graphic objects, common object types in virtual environments are multimedia data, documents, and internal/external links.

While the information space model is synchronized between all users, the visualization is not. This allows a much more flexible handling and dynamic changes between close and loose collaboration. While the local workspace is bounded, the global workspace (i.e. the information space) is not. Users also can have different views on the (global) workspace. A differentiation between the global coordinate system of the information space and the local coordinate system of the local workspace is required. The visualization therefore is a projection from the information space to the local workspace. As part of the global workspace, the information objects are also being projected. This allows assigning multiple representations for a single object type. Two possible representations are a workspace representation, like an icon or label, and a detail representation, which enables access to all object information. The visualization of links between objects strongly depends on form and complexity of the chosen link model.

For the interaction with the information space, a minimal set of object operations has to be realized: *creation*, *manipulation*, *movement*, and *deletion*. Interaction between users takes place through interaction with information space objects, so a small extension to the set of object operations is required: *selection* and *deselection*. An object can only be selected if it is not selected by another user. In addition to the object operations, *linking* of objects has to be provided as inter-object operation.

'Workspace Awareness' is part of visualization and interation. It comprises all mechanisms which support the awareness among the users interacting in the (shared) information space. For visual awareness mechanisms, an additional information channel is needed, which allows identifying the interacting users easily. An appropriate channel is available in form of coloring. Because the workspace visualization realizes loose WYSIWIS[3], awareness mechanisms for loose and close collaboration are required. In a loose collaboration, a user must be informed *where* the other users are acting. In close collaboration, a user must be informed about *what* the others are doing.

4 IMPLEMENTATION AND EVALUATION

The so-called Synchronous Learning Environment (SLE) is a sample implementation of the concept introduced in section 3. It is divided into four separable modules: data management, user management, communication, and workspace. The modularization has several advantages: It allows to enhance or to replace single modules without affecting the others as long as the interface is maintained. For example, the communication module can either be a voice or a video chat depending on user preferences, bandwidth or hardware requirements.

The user management module provides user identification and user session handling. The data management module is informed about information space changes and maintains a persistent representation. In the current version, the communication module realizes a simple voice chat. Central element of the SLE is the workspace module. It is built as client-server achitecture. The server provides a reference model of the information graph. The clients share the global workspace and are responsible for projection, visualization and interaction.

The considerations in section 3 leave room for models of different complexity. The currently implemented information space model is a minimal model according to the findings. The information space has the form of an information graph (two-dimensional), is unbounded and provides the functionality of placing information objects in an origin-centered, real-valued coordinate system.

Implemented information object types are: *Label*, *Image*, *Binary*, *URL*, and *Graphlink*. *Label* is a simple single-line text object. *Image* is a container for JPG, PNG, and GIF graphics. A *Binary* object corresponds to the 'universal' object and handles arbitrary binary files. External and internal links are realized with the *URL* and *Graphlink* object types. Links are realized as simple non-directed 1:1 mappings.

[3]What You See Is What I See

The implemented Workspace Awareness includes mechanisms for close and loose collaboration. Close collaboration is supported with colored selections and viewport tracking. Colored projections of all viewports on a map simplify orientation during periods of loose collaboration.

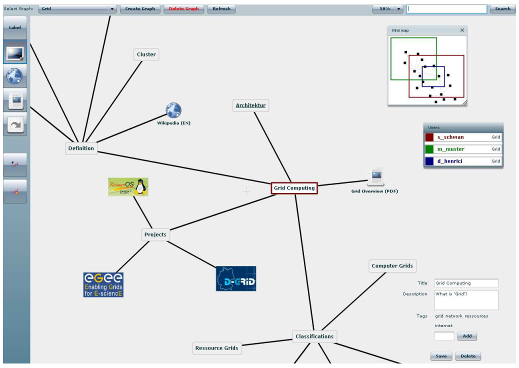

Figure 2: Synchronous Learning Environment

The evaluation aims to analyze the concrete model selection done in the sample environment *SLE*. The SLE was tested in groups of two and three users. The test started with a blank information space. The topic was unknown to the participants to create an equal level of knowledge. Information material was provided in digital form.

The basic information space structure was accepted by all users. The unbounded global workspace accommodated the demands of a dynamically growing information space much better than a bounded workspace does. Information objects of type *Label* were significantly more often placed than any other types. Beside this fact, the usage of other object types strongly depends on the form of the provided information material. As extension to the given set of objects, a type which provides the possibility of holding complete text was requested. In many situations the possibility of changing the object type was required. This functionality is therefore an important feature for further implementations. The available 1:1 mappings given by the implemented link model fulfilled the users' needs whereas a feature to measure a links weight was missed.

The implemented concurrency handling worked well in learning groups of the given size. It has to be observed how collaboration efforts scale with the number of members in larger groups. An extension showing the current actions of the other users (like 'editing', 'navigating', and 'idle') was requested. In the testing groups, this information was exchanged with the help of voice communication. All in all the provided voice communication was rated as a very important element for the collaboration.

5 CONCLUSIONS

The aim of this work is to virtualize a scenario in which knowledge is built up via information structuring. Such a virtualization provides the possibility of distributing the collaboration. With the information space model, a concept is created which enables a close cooperation. Aspects of coordination are taken into account with the construction of adequate passive awareness mechanisms. A high quality voice communication completes the functionality.

With the SLE, an implementation for the created concept is available to demonstrate its applicability. It enables an early evaluation of the concept, which is at its current state limited to usage experiences. Therefore the evaluation does not replace a comprehensive study about advantages and disadvantages of unmoderated learning in a two-dimensional information space as developed in section 3. So next, such a study needs to be performed, ideally based on a full-featured and refined implementation of the concept.

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